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AN EXPEDITION
THROUGH
THE YUKON DISTRICT

BY CAPTAIN WILLIAM H. BURNETT



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THE NATIONAL GEOGRAPHIC MAGAZINE

AN EXPEDITION THROUGH THE YUKON DISTRICT

BY CHARLES WILLARD HAYES

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INTRODUCTION.

An expedition in the interest of a syndicate of newspapers was organized in the spring of 1891 by Mr Frederick Schwatka for exploring portions of the Yukon basin in the British Northwest Territory and Alaska, particularly the region lying north of the St Elias mountains. A request was made to the director of the United States Geological survey for a geologist to accompany the expedition, and it was the good fortune of the writer to be detailed for that duty.

Under the conditions of travel only a hasty reconnaissance of the region traversed was possible, but so little has been known of it geologically or otherwise that such observations as were made possess a value out of proportion to their completeness. It is the object of this paper to give in systematic form the main facts of scientific interest observed during the journey. A full account of the journey itself, which is not without interest, cannot be given here, but will appear elsewhere through its appropriate channels. Enough of the narrative will be included, however, to indicate the route and means of travel and something of the conditions under which the scientific observations were made.

Mr Schwatka's original plan was to go over Chilkoot pass and down the Lewes, following the regular miners' route to the interior; but on reaching Juneau, at the request of the citizens, backed up by their substantial assistance, it was decided to go in by way of Taku river, with a view to determining whether a trail for pack-animals could be constructed over that route.

Considerable information of an indefinite sort was available concerning the country to be traversed before reaching Lewes river. The pioneers of the Western Union Telegraph company crossed the upper portion of the Taku basin in passing from the Sukhne to the Lewes, but the map which resulted from their explorations is only a very crude approximation to the topographic facts, and must have been drawn largely from memory.

Dr Dawson obtained from a prospector named Boswell some information concerning Teslin river and lake Ahklen which he embodied in the map accompanying his report on the Yukon district. The location and form of the lake proved to be remarkably accurate, though the regularity of the topographic

features of the region is such that a clear idea of their relations is easily obtained even without instruments.

The whole of the route from Taku inlet to the Lewis was traversed in the spring and summer of 1880 by a party of eight miners, among whom Mark Russell, a member of our party, was a leading spirit. They started from Juneau before the ice was out of the river, hauling their outfit on hand-slides so long as the snow lasted, and then packing them. It required eighty days to reach the lake, where the party built a number of boats. After prospecting the Nesutlin and other streams on the eastern side of Ahklen valley they went down the Teslin and back to the coast by Lewis river and Chilkoot pass. This is an example of the many unheralded expeditions which the Alaskan prospectors have carried out, facing dangers and privations which appear incredible to one who is not familiar with the men themselves. Less arduous or novel expeditions have brought fame to explorers better versed in the art of advertising than these unassuming miners. Unfortunately, however, geography is but slightly the gainer from the work of the prospector, since he usually has neither the training nor the inclination to use instruments even if he should be supplied with them, which is rarely the case, and ordinarily the map which he draws from memory, unassisted by notes of any sort, is not a model of accuracy.

At the head of Taku inlet a "track survey" was begun and carried continuously to the mouth of Teslin river, where it connected with the line surveyed by Mr Ogilvie in 1886. The instruments used were a prismatic compass for determining direction, and a sextant for latitude. Distance was obtained during the boat journey on the Taku, lake Ahklen, and Teslin river by time and eye estimates, and on the portage between Taku river and the lake by pacing. Altitudes were determined from the mean of four aneroids with synchronous readings of a barometer at Juneau, for which we are indebted to the kindness of Mr E. S. Willard. The route was plotted in the note book and relief indicated by sketch contours; all prominent points within sight along the line of travel being approximately located by compass bearings. While such a survey does not, of course, possess the precision of an instrumentally measured line, still, when carefully executed, it represents the character and relations of the topographic features of a country with a fair degree of accuracy.

Between Yukon river and the St. Elias mountains lies a large area, embracing the whole of White river and its tributaries, as well as the headwaters of the Copper and Tanana, which has been geographically a blank. So far as can be learned it had never been penetrated by a white man, and the lakes, rivers and mountains which appear on many maps are products of the geographer's imagination. Across this unknown region a track survey was made similar to the one already described. Excepting about fifty miles traversed by water, the whole distance of 330 miles from Selkirk on the Yukon to the junction of Chitena and Nirzenah rivers was carefully paced; and the two ends of the line being located by astronomic observations, the former by Ogilvie and the latter by Allen, the location of intermediate points cannot be far out of the way.

The portion of our route between the mouth of the Teslin and Selkirk, at the junction of the Lewis andelly, had already been twice surveyed, first by C. A. Homan, the topographer of Schwatka's party in 1886, and more accurately by Ogilvie in 1887. Chitena and Copper rivers had been surveyed by Allen in 1885, so that no continuous survey of these rivers was undertaken though numerous observations were made to supplement those embodied in Allen's map.

NARRATIVE OF THE EXPEDITION.

Our party consisted at the start of three white men—Mr. Schwatka, the prospector Mark Russell, and the writer—with seven Indians engaged as boatmen and packers for the first stage of the journey. After a few days spent in completing the outfit and waiting for the river to become free of ice, we left Juneau May 25, 1891.

The large two-ton dugout canoe in which we embarked was well adapted for navigating the deep waters of the inlet, but we found it poorly suited to the swift and shallow river. When the wind blew up stream rapid progress was made in spite of the current by spreading two large sails wing and wing, but when the wind failed our progress, by poling or tracking wherever the banks permitted, was painfully slow. Seven days were spent in reaching the head of canoe navigation, eight miles above the South fork and about eighty from Juneau. During this part of the journey little opportunity was afforded for studying the

geology of the region traversed, since the boatmen generally kept to the middle of the valley and we usually made camp at night on one of the small islands which separate the river into many channels.

While Taku river is far from being an ideal highway to the interior, still a flat-bottomed steamer of light draft and good power would probably have no serious difficulty in reaching the mouth of the South fork, less than a hundred miles from a point on lake Ahklen which could be reached by steamer from the mouth of the Yukon. The country intervening between these points is practicable for pack-animals with the expenditure of comparatively little labor in constructing a trail. It is probably only a question of time when some better way of reaching the upper Yukon basin than Chilkoot pass will be demanded, and the Taku route is, so far as yet known, the least objectionable.

At the head of canoe navigation our outfit was made up into twelve packs of about one hundred pounds each for the portage of eighty-five miles to the head of lake Ahklen. As there were but six packers, each was obliged to make two trips; so that our progress was extremely slow. The first twenty miles of the portage are in the narrow canyon-like valley of an eastern branch of the river, and the next fifty in broad valleys of the upper Taku basin, from 3,500 to 5,000 feet above sea level. The last fifteen miles are in the densely wooded Ahklen valley among innumerable small lakes and ponds. We reached lake Ahklen June 16, and from this point the Indians were sent back to the coast. It was with a feeling of great relief that we watched them disappear on their homeward journey and knew that we were no longer dependent on their caprice.

Setting up the two portable canvas canoes which had been packed in from the coast, we continued our journey toward the northwest, down lake Ahklen and Teslin river, which forms its outlet. The Lewes was reached June 24 and Selkirk, at the junction of the Lewes and Pelly, four days later. The original plan had been to continue down the Yukon to the mouth of White river and up that stream so far as possible by boat, but the Indians whom we found at Selkirk told us the easier route to the head of White river was overland, keeping southeast of the main river valley; and this route we decided to follow.

A store has recently been established on the site of old fort Selkirk, the Hudson Bay company's post, which was burned by

the coast Indians in 1848. The trader, Mr Harper, was down the river and we found only a couple of Indians whom he had left in charge. These were dispatched up the Pelly to collect the natives in the vicinity and we soon had about forty of them camped around us. Only a few of them, however, were able-bodied men, and it was extremely difficult to persuade these to go with us; and when they had promised it was only to back out the next day. After laboring with them for over a week it seemed that the attempt to secure the necessary packers was hopeless, and we were preparing to go down to the mouth of White river and try the ascent by boat, when the tide was turned by the opportune arrival of a prospector, Frank Bowker. He had come up the river from Forty-mile creek, intending to spend the summer prospecting in White River basin. With him were two natives from further down the river, muscular and willing fellows, very different from the wretched specimens from Pelly river. Bowker's arrival, as he came with authority from Mr Harper, who has great influence over the natives, put new backbone into our enterprise. Five packers were soon secured, who promised to go with us to the country of Sednaï, beyond the mountains. Dogs were obtained to carry the remainder of the outfit, from twenty-five to forty pounds being packed upon each in panniers of birch bark or moose skin.

On July 9 our combined party of four white men, eight Indians, and eleven dogs left Selkirk. Our course lay toward the southwest, over the great interior plateau which stretches from the Yukon to the St Elias mountains. The headwaters of Selwyn river were crossed and several eastern tributaries of White river.

The country is very scantily peopled, and although we probably saw most of the natives inhabiting the White River basin they only numbered altogether between fifty and sixty persons. The first party, consisting of six families, was camped on the Nisling, making a fish trap in anticipation of arrival of the salmon, which was anxiously looked for. These Indians are closely related to those living on the Pelly. They are similar in appearance and mode of life, and apparently speak the same language. They have no permanent dwellings, but several substantial log caches were seen, which they use for storing their winter's supply of dried fish and moose meat. The country seems to be fairly well supplied with game, goats on the highest

rocky summits, moose and bear in the river valleys, and reindeer or barren-grounds caribou on the plateau above timber line. Several of the latter were killed by members of our party, and our supply of provisions was also helped out by the dried meat which we obtained from the natives. On the Klumath was found a second party of Indians, most of whom had never before seen a white man. Obtaining a number of rafts from these natives we descended the river about fourteen miles to its confluence with the Donjek, since both the Klumath and Donjek were too deep and rapid to ford. The Klutlan was also found to be unfordable, and we were compelled to go around its head and cross upon the glacier from which it flows. Although this was not attended by any special danger it caused great dismay among the Indians, who regard a glacier with superstitious terror.

About twelve miles beyond Klutlan glacier we reached a small stream called the Klet-san-dek, or Copper creek, coming from a narrow gorge in the mountains. This is where the Yukon Indians have been accustomed to come for supplies of native copper. It was as far as any of our packers had ever been from home and they knew of the country beyond only by report. They refused to go with us further, assuring us that it was quite impossible to get through the mountains at that season since the pass was only traveled by Indians in the winter on snow shoes. Bowker had already come further than he originally intended, so that he turned back with the Indians. It was something over two hundred miles back to Selkirk, and although through an unknown country a considerably shorter distance to an Indian village on the other side of the mountains. Trusting in our ability to reach the latter inside of two weeks, a period for which we had provisions, we decided to push forward. Discarding everything not absolutely essential our packs still amounted to seventy-five or eighty pounds apiece, so that progress was necessarily slow. The weather since leaving the coast in May had been very warm, with little rain except local thunder showers, but from this time until we again reached the coast rain was falling most of the time. As we had no tent, this added greatly to our discomfort.

Leaving the Klutlan, our party now reduced to three, we continued toward the northwest through the densely wooded valley, with the White river on our right and the steep mountain face on the left. At the end of the third day we came out upon

White river, flowing from the south in a deep narrow valley. This we concluded must be the pass of which the Indians had told us, and our belief was strengthened by meeting a high wind, amounting almost to a gale, blowing through from the south. A couple of miles back from its mouth a wall of moraine-covered ice stretched across the valley, the river emerging from a tunnel on the extreme western side. This was undoubtedly the ice which the Indians said it would take us at least four days to cross. As usual, however, their statement was wide of the truth. Crossing a couple of miles of rough moraine-covered glacier with a gradual ascent toward the south, we came to a long stretch of firm white ice upon which walking was a positive luxury after our days of floundering in the deep moss and alder thickets of White River valley. We continued to ascend gradually for about ten miles, directing our course toward a low saddle in the mountains on the south which we supposed to be the pass. Toward evening, however, we were surprised to find the surface of the glacier descending and a little later discovered a deep narrow gorge turning off to the right almost at right angles with our former course. We had crossed the divide, and in a short time were off the ice and camped on a stream flowing into the Pacific. This was the Nizzenah, a tributary of the Chittinah, or eastern branch of Copper river.

The next four days we continued our journey down the narrow canyon which this stream has cut through the mountain range and encountered the most difficult traveling we had yet found. The vegetation on the southern side of this range rivals in luxuriance that of the coast. Forcing our way through the dense growth of alder and spruce which covers the steep slopes at the base of canyon walls was extremely slow and painful work. A mile in four or five hours was counted fair progress.

At length, after having been compelled to ford the river several times, we reached a point at which it appeared not wholly impracticable for boating, and it was decided to stop and build a boat. Our tools consisted of a very dull axe and our pocket knives, but with these we hewed out a keel and gunwales from spruce saplings and fashioned ribs from willow poles, lashing the structure together with twine unravelled from our pack ropes. Over this frame was stretched the canvas in which our bedding had been wrapped and finally the covering was smeared liberally with spruce gum. In this craft our progress was more rapid and

and wide of extent. The river has a fall of about twenty feet to the mile, so that it is practically a continuous rapid from the point where we embarked thirty-five miles down to its confluence with the Columbia. For seven miles above the confluence the river flows through a narrow, rocky waste from which no soil is high. It is extremely narrow and crooked, the water, above the canyon frequently spread out half a mile or more at the top, compressed into channels in places only a few yards across.

We were presumably on a part of the river descended by La Motte and Allen in 1880 with a crew of natives, but this far had been unable to make the portage fit for any mail were no doubt until we reached the lower end of the canyon, where it was of less interest to know that another had been through that it would have been before we started in. After endeavoring with minor success to gain something of the character of the canyon from the top of the falls, we decided to attempt the passage. Our boat was tossed from side to side of the narrow channel, which at times projected up to the brink and then a narrow channel with a rock or a sand bar took our trail. Twice more the canyon wall was so close that we were unable to see.

In a short distance we had several times come uncomfortably near disaster and that we got through in safety is largely due to the coolness and skill with which Mark Russell navigated our crew.

Just as we were about to reach about forty miles below the lower end of the rapids we reached Tatal, a few miles below the mouth of the river, August 12, just thirteen days after the natives left. We left Tatal. We had made a goodly haul of goods and had taken with three packs of light baggage. We had a lot of mail and the provisions with which we left Seattle.

At Tatal we saw a Mr. J. C. Seaborn, the Y. M. C. A. agent and called on him for a letter of introduction to the natives. He gave us a most helpful receipt for our supplies as well as provisions as far as the native stores permitted. Seaborn, with fresh and dried, were abundant, so that we had no further apprehensions of hunger. The natives of the river, who are here in considerable numbers for a long and healthy to the whites, but we saw none along the journey. They are pretty superior to the Y. M. C. A. natives, at least and are much more intelligent than the natives of the coast.

We were so fortunate as to reach Tanai just as Nicolai was preparing for his annual visit to the coast, and after a delay of four days we embarked in a large skin boat manned by ten of his vassals. A couple of days brought us down to Miles glacier, where the river tumbles over a dam of huge moraine boulders. It is necessary to make a portage here sometimes across both moraine and glacier. Crossing about two miles of moraine covered with a dense alder thicket, we came out upon a high ridge of freshly deposited boulders. Immediately in front was a broad expansion of the river—a front of the glacier, which formed an ice cliff along one side nearly four hundred feet in height. Icebergs were almost constantly falling with reports like a bullet, landing the spray high above the top of the cliff. The current of the river sets a race the like toward the foot of the glacier, and whenever the swell produced by a falling mass of ice the water is torn into enormous breakers which, with the grinding icebergs, would swamp a boat instantly. Nicolai deemed that we might get past by waiting for a fall in the falling of the ice and for a wind from the right to create a current a passage through the floating bergs. The right moment came after a wait of nearly a day, and turning the logs into the boat we were soon past the dangerous spot, to the evident relief of Nicolai and his crew. A short distance now we passed the front of Miles glacier, ranging within a stone's throw of the lofty wall of ice and found ourselves at the head of the river delta, with the blue Pacific in sight far to the southward. It took a few days of being there as this since we had left the coast at Jukuan, and at that time we had traveled almost exactly a thousand miles, nearly half the distance being on foot.

Nicolai intended going to Eysa, where two salmon canneries are located on a narrow neck of the peninsula between the Copper River and the Prince William Sound. Within a few miles of that place we were met by a native with the report that the Eyak canneries had closed and the trail was closed. This report, which we afterwards found to be the real trouble, turned us back to the head of the delta and it was not until nearly fifty miles out of our way and delayed our arrival at Eyak about four days. On account of the delay we missed the August mail steamer from the sound by twelve days and were obliged to wait there a month for the

1.5 C. W. Hayes—*Laptevum through the Yukon District*

The coast from Takot inlet to Cape Smyth and also from Icy Bay to the western edge of sheet 11 is from the general chart of Alaska, a further 800' added by the United States Coast and Geodetic survey, Washington, 1st ed. The topography of the region is well shown by a sketch between Seakirk at the confluence of the Icy and Klondike rivers, and the mouth of the Alyeska, a country track survey, the greater part of which was made in 1885.

The Yukon from Seakirk to the edge of sheet 11 is from the sketch survey by Charles A. Johnson, published as sheet 2 of map accompanying the report of a military reconnaissance of Alaska, made in 1885 by Lieutenant Frederick Schwatzen (Washington, 1885).

Chitnah river and the immediate Wrangell region are from a survey made by Allen in 1887, sheet 2 of map accompanying the report, an expedition to that of por, Tanana and Koyuk rivers, of the territory of Alaska, in the year 1885 by Lieutenant Henry T. Allen (Washington, 1887).

The coast from Icy Bay to Yakutat Bay, with the river toward the north including the St. Elias, is from the sketch of Allen in 1880 and Russell in 1891, combined and enlarged at the request of the government by a report published in 1891 at St. Elias and its environs by Lewis C. Klawns*.

Mountains and Coast

From the valley of Fraser river, now called Franklin and the western foothills range, the Collierian mountain system follows the coast westward. Here it becomes an interior range, which however would be joined to the coast as like to the St. Elias range. The southern Alaskan coast mountains begin a low elevated ridge with many small out peaks, which however perhaps has a number of more than 5000 ft. high peaks, as there is no low mountain. The south western front of the range rises abruptly from the waters of the Icy Bay passage, forming a rugged barrier to the interior. A few rivers have cut their channels through the range, but it is penetrated, varying distances by an more or less narrow from the head of Icy Bay, and northward the range becomes more and more gradually spread out at distances in the lower

* *Alaska Journal*, 1st series, vol. xii, 1, 1892, p. 13.

plateau which covers the eastern part of White River basin. This region is practically unknown, however, and the precise relation of the Coast range to the St Elias range has not yet been determined. Whether the former range is cut through by Taku river its northeastern flow, like its northwestern terminal one, is not sharply defined but the mountain range merges with the high plateau lying to the eastward between the Coast range and the Rocky mountains.

The St Elias range appears to be divided into separate and more recent uplifts. Its continuation southward is partially submerged and forms the islands of the Vancouver and Puget sounds. Still further southward, the Queen Charlotte and Vancouver coast islands form a range called by Dawson the Vancouver range, the westernmost member of the Cordilleran system. Like the southern coast range, it is a broad elevated land with numerous peaks and short ranges, probably the highest being among its southernmost culminating summit Mt. Elbert. Westward from this peak the range is separated into two divergent ranges by the valley of the Fraser river. The one of them toward the north-west contains the high volcanic peaks of the Wrangell group. The southern divergent range follows the coast toward the west as far as the region of Prince William Sound, then turns toward the south-west in the Kenai peninsula or perhaps Kachikak island.

The eastern limit of the Coast range may be fixed approximately at the junction of the

Taku, the region east of this being a high plateau which may be called Coast range, the northern representative of the ranges of British Columbia. A peak rising off the interior plateau where the river is passing from the Taku to Lake Atkasien, is about 5,000 feet above sea level. From this point it descends gradually to where the river west, its altitude at the junction of Lake Atkasien river is but a little less than 4,000 feet. Southwest of Seakirk the same plateau extends with gradually increasing altitude to the base of the St Elias mountains. It is very irregular way, however, and these areas are of irregularly irregular shapes. When rising and in land the surface is extremely rugged and broken. The river valleys are from 1,000 to 2,000 feet and the general plateau level, while broad and rounded like the same, is not a few sharp peaks rise from 1,000 to 1,200 feet above it, but there appear to be no well defined ridges or sharp peaks. For about 10 miles south-west of Seakirk the

contours are generally smooth and flowing, and the surface except in the southern and glaciated portion of the region, shows the effect of long continued exposure to the action of subaerial agencies. While rock decay has made little progress so that the surface is practically free from soil, rock disintegration has been extremely active and the country is thickly mantled with rock debris of varying degrees of coarseness. Projecting through this mantle of debris above somewhat gentle slopes, are more isolated peaks and towers of rock rendered especially conspicuous by contrast with their moss-covered talus slopes. Surface degradation is greatly retarded by the luxuriant growth of moss which covers practically the entire surface of the country. The rainfall and precipitation is largely confined to the winter months, and the water from the melting snow is held by the sponge-like moss, which remains saturated, throughout the year but not the dry summer. Thus, with a rainfall which in lower latitudes would be considered moderate, a large part of the surface is swampy, quite irrespective of slope, that is, wherever the material composing it is sufficiently compact to become impervious to water by freezing. On account of this slow and imperfect surface drainage the slopes are not cut into the ravines and gorges so characteristic of arid regions. The plateau extends west of White river, though it is there rather more diversified than toward the east by a number of high sharp peaks probably of volcanic origin.

Approaching the northern base of the Stikine range the plateau character is almost wholly lost, giving way to steep and rugged mountains divided by rather wide river valleys. There is, however, no mingling of the glacial and the Stikine mountains but south of a well marked line the whole character of the topography suffers a complete change. Between the southern end of the interior plateau and the northern base of the Stikine mountains is a depression running parallel with the mountain range and having an altitude of about 4,000 feet. It extends the upper half of White river for a distance of about thirty miles and probably has in a former western position the headwaters of the Tanana. As I moved across this depression I was soon to the abrupt northern face of the Stikine mountains, where very sharp and rugged peaks rising to altitudes of 10,000 to 12,000 feet. Only the steepest slopes were free from snow and the region presented a striking

contrast to the green, moss-covered plateau country toward the north. The range here occupies a belt about eighty miles in width from north to south. Mr Russell saw the same region from the eastern flanks of Mount St Elias, and he describes it as "A vast snow-covered region, limitless in its expanse, through which hundreds and probably thousands of barren, angular mountain peaks project. There was not a stream, not a lake, not a vestige of vegetation in sight. A more desolate or a more utterly lifeless land was never beheld. Vast, smooth snow surfaces, without crevasses or breaks stretched away to seemingly infinite distances, diversified only by jagged and angular mountain peaks."⁴

Drainage

The Taku, like the Stikine and other rivers toward the south, is flowing in a deeply eroded channel, even though the land stood relatively small later than at present. Its valley was a wide extension of Taku inlet, is from one to two miles wide, with steep sides rising to the plateau almost vertically from 3,000 to 5,000 feet. The river, interrupted by many small bars and low windrows of ice, flows over a gravel bottom, half between the high walls of the valley. Its current is rapid and it is transporting to the inlet great quantities of sediment from its upper course. Beyond the junction of the northern and southern forks, which may be regarded as approximately at the eastern limit of the Coast range, the valley sides are rather steep to an elevation of about 1,000 feet from the river, walls above that level the slopes are gentle to almost horizontal summits of the interior plateau. The upper branches of the Taku flow in other valleys from 3,000 to 4,000 feet above sea level, indicating a rapid rate of erosion. It is probable that the land stood at a much lower level at present. Similar conditions as the upper courses of many rivers in British Columbia have been referred to by Dawson (1901) as it was common in mid-July time, and it is probable that the same conditions prevailed as far to the north.

⁴Mount St Elias and its glaciers. Am. Jour. Sci., 3d series, vol. xli, 1892, p. 15.

⁵On the glacial history of the rocky Mountain region of Canada, with special reference to changes in elevation and the history of the glacial period. Trans. Roy. Soc. Can., vol. xii, ser. 2, 1908, pp. 7-24.

were produced, great broad valleys of the upper Taku tributaries. The broad valley-like valleys in the lower portions of the river again represent a part of the erosion due to uplift in the Fortymile and Platon ranges.

The divide between the Taku and Yukon drainage basins is on the edge of an escarpment by which the surface drops from the high plateau 2000 feet to the level of Atkasook valley. The altitude of the pass is 5100 feet, which carries roads very nicely with the average altitude of the interior plateau at this point. The divide is from twelve to twenty miles broad, and on its eastern side is the steep edge of a plateau continuing to the mountains on the west and extending eastward to the base of the Cassiar range, forty or fifty miles beyond. The divide is therefore nearly parallel to the escarpment, and the valley extends in an almost perfectly straight line for at least 200 miles from the west to the east horizon. The river that is the southeastern end of the valley is occupied by lakes. From one point on the escarpment obtaining a partial view of the valley, fifty lakes were counted, and these lakes Atkasook is the northernmost and also by far the largest. This lake is nearly four miles in length and from half a mile to three-quarters of a mile wide. Several small streams enter the upper end, but the main feeder comes in from the northeast about halfway between the head of the lake and its outlet. This stream is the Nukuk, and it is a curious thing that it is not long enough to reach the outlet at a right angle to the direction of the lake. According to Mark Cassell, who is prospecting the stream, the current is very sluggish, and even in the summer months it is above the level of the ice.

Several times along the valley south of the little lake, except where the bounding escarpments draw some what closer together and are therefore a little steeper, the drainage after a part of the winter flows into the north. At the same time it is a fact that the river which flows southward from the head of the lake is not a feeder of the lake, but a feeder of the Nukuk. The Nukuk is a very curious stream, and it is a very curious thing that it is not long enough to reach the outlet at a right angle to the direction of the lake. According to Mark Cassell, who is prospecting the stream, the current is very sluggish, and even in the summer months it is above the level of the ice.

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And still another thing is a fact that the river which flows southward from the head of the lake is not a feeder of the lake, but a feeder of the Nukuk. The Nukuk is a very curious stream, and it is a very curious thing that it is not long enough to reach the outlet at a right angle to the direction of the lake. According to Mark Cassell, who is prospecting the stream, the current is very sluggish, and even in the summer months it is above the level of the ice.

formation in the Lake Athabasca brings up the whole subject of the nomenclature of the Yukon and its tributaries. The subject has received very thorough treatment by Hall, Dawson, and Russell,* and the history of the river in the Yukon basin and the origin of the names applied to the Yukon tributaries need not be discussed here. From a cartographical and physical point of view the basin of this river must be regarded as a unit. As Allen says, "I do not hereby agree with Russell's view of the Yukon as a geographical unit, but for disregarding well-established usage, as he has done in combining the name Yukon up to the lake."† However, as the river in question is almost wholly within Canadian territory, the final authority upon the nomenclature must be the Canadian board of geographers, and as Mr Dawson has given the subject the most thoughtful consideration I have followed him with a few minor changes in the rest of which he has signified his concurrence. The name *Yukon* is applied to the river from Selkirk to Selkirk. The name *Pelly* is confined to what has been called the "upper Pelly" or, from Selkirk to its head. The name *Liard* is applied to the river from Selkirk to Lake Liard and is called the "Yukon" by Selkirk. Finally the river flowing from Lake Athabasca enters the *Teslin*, that being the native name as determined by Selkirk and Dawson, with the generic portion dropped. (As Selkirk gives "Teslinna" it is probably Teslin.)‡ And Dawson, "Teslinna" for "bina" and "be" are generic terms for river, so it is properly Teslin river. The name *Assiniboia*, applied to the river by Selkirk in 1883 has never come into general use, and the name *Liathoupa* which is common only used by the Indians, was as Dawson has shown transferred through misapprehension from another tributary of the Liard.

The floodplain of Teslin river is not, though over a mile in width, between high banks of silt and gravel which will be more fully described under the head of gravel, denudation

* Notes on the Surface Geology of Alaska. Bull. Geol. Surv. Am., vol. 1, 1880, p. 15.

† Report on an Expedition in the Yukon District, N. W. Territory, and adjacent northern portion of British Columbia, in 1887. Ann. Rept. Geol. Surv. of Canada for 1887-88, vol. 3, pt. 1, 1889, pp. 194-195.

‡ Report of a Military Reconnaissance in Alaska made in 1883, Wash., 1884, map, pt. 1, sheet 4.

The current is from four to six miles per hour and, except for a few sluggish sections near the Lika, is quite uniform throughout. The water was exceptionally high in the spring of 1891, a water, so it has been found to increase the uniformity and velocity of the current. There are no shoals or rapids which would prevent the passage of a river steamer from the mouth to the head of the river.

The course of White river except for a short distance near its mouth, has hitherto been entirely unknown. Some explorers are said to have spent a winter at the first fork, about sixty miles from the Yukon, but beyond that they have failed to penetrate, probably because of the impassable character of the stream.

It is difficult to conceive physical obstacles so readily for-
 bid to turn back these hardy explorers.

The White River basin was entered by the writer fifty miles from the mouth of the river. From the high hills between the Nishan and the Longkuk mountains a view could be seen for a long distance toward the south, with the river pursuing its extremely tortuous course among the mountains and low lands and rivers. At one point nearly a hundred miles of the Nishan the river pursued a right angle turn of a hundred miles by a narrow canyon, probably a case of superposed canyons due to the successive turning of the valley by ice. Part of the old world it turns sharply toward the west and enters a long narrow valley, in which, by native report, there are many dangerous rapids.

For the first seventy miles in the White River basin only clear little streams were crossed. The largest of these, the Nishan, probably drains the greater part of the large area bounded on the east by the Tula-sang mountains, and it is very nearly the position which a lower range assigned for the main White river would hold in part of its watershed. The high coast range

which by the greater part of the northward flowing drainage of the St. Lawrence drainage is carried off by numerous tributaries of the White river, would show another evidence of glacial origin in its extremely high ridges. The Ibuk is the largest stream to be

* In naming the tributaries of White river I have followed usage among the natives and also so far as possible. Some of the names are somewhat uncertain and do not seem to be a pronunciation of a definite word. A part of the name has been changed, as "toy," meaning river and "lek," creek. The names, however, are near enough to the original forms to be recognized by the natives, and used as

bury, and here via the northward drainage from the greater part of the St. Elias mountains east of the 141st meridian. There was some question as to which branch should be regarded as the main river and which the tributary, but the western is more central in the axis of the main valley and is probably also somewhat larger than the Jompek, although no satisfactory comparison could be made as the country was not seen. The western branch rises in Sochar pass from the northward flowing lobe of Russell glacier. In the fifty miles of its course lying west of the international boundary it receives a number of tributaries from the south all of which flow from glaciers. This part of the river is in constant motion. It flows in many channels, constantly shifting its position upon a wide gravel plain which is being built up by a continuous deposit of coarse sediment from the overlying stream.

Sochar,* pass is a low pass through the range which extends north westward to the Wrangell group. Russell glacier, from the southeast, flows into the pass against the steep western wall, which turns a part of the stream northward into White river and then turns a smaller lobe toward the south, so that for about ten miles the pass is filled with ice at least several hundred feet in depth. The altitude of the divide, which is near the northern edge of the range, is 5,400 feet, or about 1,000 feet higher than the upper White River valley. The southern lobe of the glacier gives rise to the Socharh river which flows at first westward through a deep, rocky, U-like valley for fifteen miles, and then nearly southward about twenty miles, emerging into the valley between the two divergent mountain ranges already mentioned. At the point where the river makes its sharp bend toward the south a glacier comes up into the valley from the northwest and dammed its waters so as to form a lake several miles in length. Pushed out of its old channel by the ice, the stream flows a short distance across a rocky point and then plunges over a tumbling ice fall from which it carves half a mile below. After leaving the mountains it flows nearly westward for thirty miles, where it confluent with the Chitnah and the latter stream continues on the same course about fifty miles farther to Copper river. These highly polished areas in a rather broad open valley,

* "Sochar" is the name by which the Copper river chief, Sochar, is known among all the Yukon natives.

these mountains were very much forested when the ice had withdrawn which has been covered with snow. The forest was not continuous to the coast, but also very much broken in the interior. The timber was then in a decreasing condition with increasing altitude from the twelve feet in the valleys to a few feet on the higher mountains and the plateau. The upper limit of the spruce forest is about 10,000 feet above the coast at an altitude of about 15,000 feet. It is not far long with the snow, but gradually more is uncovered.

The high valleys of the Yukon to the westward were forested spruce timber and the spruce trees are now coming to the edge of the forest and are not so much over a foot in diameter. The spruce with its latitude of 51° N. is approximately about 100 miles from the coast. It is a very slender tree in this range of extent.

Alder valley is a very low valley timbered and some spruce is gathered and is a distance the large spruce at valleys on the coast were a more abundant forest from the coast.

In the White River basin the valleys are wooded to the top extending less to the coast and fact in the region, which are greater part of the plateau surface is probably the forest. The timber line on the northern side of the St. Elias mountains is about 10,000 feet above the coast.

The timber line to the coast over the coast the influence of the coast climate on their vegetation is very small. The timber line is about 10,000 feet above the coast of White River basin.

Handwritten

Character of the Mountains—Any attempt to solve the mountain

problem is connected with the geology of the region. The coast was a more extensive study of large areas. The opportunities of the coast are very numerous and are along a single line of travel are obviously very small. The solution of these problems is partly solved when we are a part of the geological survey and are in the very heart of the physical sciences. The progress and in making even the crudest to our place up to which to refer to the coast.

The most satisfactory information on the land geology of any portion of this region is obtained in Dawson's report already cited, on the geology of the Yukon district. Mr. Dawson had the great advantage of familiarity with similar rocks in geological problems from previous study in British Columbia. He was a so-

in a position to control the movements of his party, and so was able to give more than a passing glance to points of special importance. But the writer was without power to begin studies of the rocks of the Cordilleran system and had no opportunity for observation, except as it was afforded along the route at stops selected without reference to the geology. The information obtained is offered only as supplementary to the observations made by others and as preliminary to the more thorough study of those who may hereafter visit the region.

Rocks of the Coast Range. The section afforded by Takli river as it cuts through the Coast range is quite similar to those described by Dawson on Skeena river and Chilkoot pass. After leaving the argillites of the coast which extend to near the head of Takli river, a broad belt of gray lamellar granite is crossed; this is called the Coast Range granite by Dawson. The belt is about 10 miles in width, extending nearly to the North fork of the Yukon. In addition to the granites this belt also contains altered igneous rocks in horizontal or truncating and somewhat irregularly contorted beds.

Rocks of the interior plateau. Forming the plateau between the Coast range and Chilkoot valley is a somewhat broader belt containing a great variety of rocks, both eruptive and sedimentary outcrops being highly altered. The sedimentary rocks consist of limestones and marbles, shales and slates with corals, corals, crinoids and quartzites. The least altered members of the series occur along the western side of the belt. At the junction of the North and South forks of the Yukon, near the mouth of the Coast Range granites, there are black slaty shales and a partly overlying lens with a dip of from 25° to 40° north eastward, and composed of thin limestone. Still farther eastward there are greenish shales with large corals, crinoids of the underlying limestone. The pebbles contain some chert and fossiliferous carboniferous which would indicate a Mesozoic or later age for the series. These slightly altered rocks occupy a belt about 10 miles wide, east of which lies a region traversed by many rivers that have converted probably very similar shales and limestones into coarse grained highly crystalline marble.

Among the non-sedimentary rocks of this plateau belt there are many basic eruptives largely altered to serpentines and also considerable areas of granite. A portion at least of the granite is older than the sediments as is indicated by basal conglomerates

at the contact. The basic eruptives are confined to a narrow strip less than a quarter of the width of the plateau belt and lying along its western side. The sequence of these rocks, as well as their relation to the Coast Range granite, is extremely involved, and much farther study will be required in order fully to determine these relations. Their age is probably upper Paleozoic and Mesozoic, though very few fossils were found and none except in the less altered western portion of the belt.

East of Alkien valley there is another belt of granite of a distinct character from that of the Coast Range. It is free from hornblende and contains a large amount of pink feldspar, a very noticeable red color to the rock in mass. The granite has in some places a well developed gneissoid structure, the cleavage being approximately parallel with the direction of the lake. Tension cracks follow a path very irregular where it and gravel so that a distance of a few hundred yards exposures are developed out to a considerable distance from the contact. The rocks on the valley are composed of rocks similar to those forming the plateau west of the lake. A northward flow is above the mouth of the river the hills toward the northeast are composed of bright red sandstone with yellow and gray shales, probably less altered than the perhaps younger and more altered rocks of the Coast Range.

The extensive plateau region between the York river and the northern base of the Coast Range is composed of coarse grained granitic rocks with occasional areas of highly altered rocks.

The granitic rocks are similar to that forming the Coast Range of southern Alaska and are a somewhat dark gray to blackish gray in mass. The ground rock is fine grained and the rock in north of the belt is a light shaly granite quite free from hornblende and free from containing large porphyritic crystals of feldspar. The thickness of granite is at best irregular and covered by a belt of crystalline rocks in the north consisting of dark basaltic lavas to highly altered diabase. The red granites above appear to be Archean, deposited upon a white crystalline mass of sedimentary rocks that have been folded by the granite and penetrated by the basaltic rocks and it is so completely changed from their original form that no trace is reflected as to their nature. They consist of arkose-conglomerates, gneisses and marbles.

West of the Klaskan valley the only elastic rocks seen are a few exposures of arkose

from that no trace is reflected as to their nature. They consist of arkose-conglomerates, gneisses and marbles. West of the Klaskan valley the only elastic rocks seen are a few exposures of arkose

gl. surface and schist. The district between the Boyer and Kalamazoo rivers is composed almost entirely of white sand and to some extent, but is the best observed area of sedimentary rocks between the St. Elmo mountains and the Yukon.

North of Beacon River.—As a readily discerned, two slightly divergent ranges separated by the Chittenden valley, extend toward the west and north-west from Mount St. Elmo. The geology of the northern range is simple. In the walls of Scudat pass, by which the range was crossed, the stratigraphy and structure are more fully displayed. The rocks are comparatively recent for the most part Carboniferous, Triassic, and Cretaceous. A bed of limestone about 700 feet thick contains many corals and corals, probably of Carboniferous age. Above it are red sandstone and jasper and a great thickness of black shale. Collections of fossils from the limestone and the black shale were made, but after reaching the coast they unfortunately were lost, with the exception of a few general pieces of corals. One, however, contained several extremely perfect impressions and was shown to me by Professor A. Louis Hyatt for identification. He says: "The fossils in the shale are clearly the remains of a *Leptæa* of a *fraseri* type, and a *Leptæa*, *Leptæa*, a *Leptæa*. The *Leptæa* form is of the same age." This one specimen is distinct enough, but it is evidently of the same age.

Interbedded with these sedimentary rocks and penetrating them as dikes are fine grained, grayish unbedded basaltic rocks perhaps half of the whole rock mass. The structure of the range consists essentially of a local gentle syncline with highly distorted or folded strata.

Excellent examples of typical *Leptæa* structure were seen in the intensely jointed rocks which form the abrupt northern face of the range. This structure is remarkably well shown in the sides of the gorge from which Kalamazoo creek issues. The last foot stratum of white limestone above red rock is folded in with dark greenish black ore, and rocks so as to form a double *V*, the overturned or other synclinal limbs dip southward about 30° and 45° , while the normal northern limbs are nearly horizontal.

This jointed belt on the north side of the range is about six miles wide, and south of it the synclinal in which the beds are practically horizontal, joined together by the axis of the range occupies a belt from twenty-five to thirty miles in width.

On the southern end of the range there is a region of disturbed rocks similar to that on the north but somewhat wider and less minutely plicated. The structure is well shown in the lower portion of the Arizona canyon, where walls rise from 2,000 to 4,000 feet vertically above the river. One excellent example of faulting was observed. A bed of white limestone about 500 feet in thickness, probably a continuation of the one in which the fan structure was observed on the northern side of the range, has been broken across and thrust over upon itself a distance of half a mile. Within this space there appear to be two conformable beds of limestone in place of one. The diagrammatic sketch in which the fault is displayed on the canyon wall confirms certain theories as to the mechanism of such faults derived from work on the viscous phenomena in other regions. Evidently faulting, due to lateral compression, had been only slightly developed when a shearing fracture took place across the rigid bed. The structure did not extend far on either side of the limestone, but the thin-bedded black shales above and below are intensely plicated, having taken up the lateral compression by folding instead of faulting. Apparently the conditions were determined too far across of a fault rather than a series of folds had developed were, first, the great difference in rigidity between that bed and the adjacent shales and second, the pressure of a heavy load upon the beds during the compression.

Arizona river, for about several miles above its confluence with the Chittagah, flows in a narrow canyon with rocky walls about 100 to 500 feet high. For a short distance above the canyon the gravel banks are replaced by cliffs of red and black shale apparently very recent and only slightly affected by the erosion, which has its effect on the rocks lying on the north. At the upper end of the canyon the black shale consists of extremely coarse conglomerate, and is succeeded by black shale and mica schist, the latter containing many small garnets. An east and west line through the upper part of this canyon appears to be the approximate limit of the little altered rocks forming the northern range.

Islands of Copper River delta—several massive dikes intersect the course of the Chittagah a few miles above its junction with the Copper, forming high cliffs and a number of rocky islands in the river channel. These dikes are composed of a very coarse granite, much like the one at the mouth of the Copper.

part greenish black rock (crystalline) and a few streaks of light green serpentine and white veins apparently of calcite. The rocks of the southern range which extends westward from St. Elias differ widely from those exposed in Selkirk pass. About Tana they consist for the most part of siliceous talcose schist with gray hornblende granites, which is apparently eruptive. Between Tana and the coast the prevailing rocks are light gray gneiss or quartz-schist. The moraines of glaciers along the lower course of Copper river flowing from the eastward are composed largely of eruptive granites and granitoid gneiss containing no masses of black slate and schist. And the sedimentary rocks between the Chitina and the coast have been ~~so~~ ^{so} thoroughly metamorphosed that their original bedding is wholly obliterated, and no statement can yet be made as to their probable age.

Rocks of Prince William Sound—Forming the shores about Prince William sound there is a series of black shales and thin bedded dark brown sandstones. They are highly metamorphosed and somewhat altered, especially the shales. The strike, wherever a regularity can be detected, is about north-and-south, and the dips are generally steep, often vertical. They bear a strong resemblance to the rocks of the Yuk that are described by Russell,* and it is not improbable that they are the continuation westward of that series. Fossil plants are reported to occur in these rocks at some points on Prince William sound but none have yet been collected. While the series is perhaps a Mesozoic or younger, any statement as to its age made at the present time must be regarded as purely hypothetical.

Mining

Gold. Fluvial gold occurs widely disseminated throughout the Yukon basin, though only in a few places has it been found in sufficient quantity to make profitable working. The most important of these are bars along the lower between Teslin and Little Salmon rivers and

bars of the Yukon emptying near the 14th meridian. Ten miles west of the mouth of the Tanana, and, although the water

* See description by Mr. W. H. St. Elias, Alaska, *U. S. Geol. Surv. Mon.*, vol. 10, 1881, p. 167.

was very high when we went down, they are said to have done well in the latter part of the season.

One member of our party, Mark Russell, was equipped with long experience in prospecting both for placer and vein gold.

As far as the White River basin is concerned, the only as possible revealed anything like an exhaustive examination, still enough was done to give a fair idea of the resources of the region traversed. While in White River basin we also had the benefit of Mr. Roaker's experience. A few "shows" were found in most of the branches of White river which we crossed, but it was all fine gold and afforded nothing which could be regarded as a good prospect. The indications of gold-bearing quartz were even less encouraging. Practically no vein quartz was seen between Selkirk and Selkirk pass either in place or among the stream gravels. Along the lower portion of the Nizenzu, and thence southward to near the mouth of Copper river considerable quartz occurs in small stringers through the sediment, so that there is a possibility of this region containing gold-bearing veins.

Copper—As we require has long been known to exist in the Copper River basin, but exactly where or in what quantity has never been ascertained through actual examination by a competent observer. Its occurrence in White River basin also has been suspected from the presence of native copper among the Yukon Indians, although they were known to trade with the natives living on Copper river from whom they might have obtained the metal. The Peley Indians whom we secured at Selkirk for packers promised to show us the source from which in the past they had secured copper for making arrow-heads and more recently for making bullets, which are still used to some extent when lead cannot be obtained. While still at Selkirk they told us of great masses of copper as large as houses on a stream called the Khet-sand-ek, or Copper creek, flowing into White river near its source. As we approached this locality, however, the masses of copper rapidly decreased in size, first to pieces as big as a man's head then to boulders of such size that they could be lifted by prying with a stout stick and finally what they actually showed us consisted of small nuggets, the largest of which weighed only a few ounces in weight.

Khet-sand-ek issues from a narrow gorge in the steep northern

face of the Mt. Elias mountains, flowing from numerous small glaciers a mile or two back from and several thousand feet above the valley of White river. At a former stage, probably when the glaciers descended to a much lower level, the stream deposited a broad alluvial cone about the mouth of the gorge. This deposit of gravel is now being cut away and in its lower portions or in crevices of the bed rock numerous small nuggets of native copper are found. This seemed to be the only locality for the metal known to the Indians who were with us, though pieces which had been cut from a larger mass were shown us by those whom we met on Klaskan river. It is not probable, however, that any of the Yukon basin Indians are acquainted with extensive deposits of native copper, since they have very little of the metal in their possession and hold a greatly exaggerated idea of its value. Some time was spent in searching for the source of the copper on Klaskan creeks but without success as we soon reached the snow line, beyond which, of course, further search was impracticable. It appears to have been brought by glaciers from the region toward the south which is so completely snow and ice. It is associated with greenish-black amygdaloid lava and red sandstone and Jasper rocks which remain, superficially at least, those of the copper-bearing series of the Lake Superior region.

A small quantity of what appeared to be azurite, pulverized and used as a pigment, was shown us by the Yukon Indians. They said it came from the country beyond Scotch pass, but we were unable to learn its exact source or how they obtained it.

According to Allen's account, the chief of the Copper river Indians told him of the existence of native copper and a vein of copper ore in the upper Klaskan valley between the two main streams, but he did not visit the locality. We expected to find a vein on the Nisutlana at the point where it emerges from the mountain pass and to be able to examine the copper of this region, but unfortunately Nelson and his men were at the station of fishing station, Tara, and it was too late in the season to return to the copper region which we had passed.

Doubtless this interest in the Nisutlana vein of Scotch pass will be based on careful examination to obtain considerable mineral wealth, but the extreme difficulty of access together with the unfavorable climatic conditions will greatly retard, if not wholly prevent, the development of its resources.

VOIRAS & TUKA MUKA

Active & extinct.

Volcanic activity in the United States within historical times has been confined wholly to Alaska, and, excepting somewhat mythical eruptions of Mount Katmai on Prince of Wales Island in 1775 and of Mount Edgucumuk in 1894 it has been confined to the southwestern extremity of the territory. The most easterly known center which shows any activity at present is Mount Wrangell. This was observed for seven days during August, 1891, from Tard, at the confluence of Chitina and Copper rivers. It lay about fifty-five miles nearly north of Tard, and only the top of the mountain, a sharp black cone, appears above the intervening broad snow-covered dome of Mount Blackburn. From this cone masses of densely black vapor were constantly rising. At intervals of time it had a minute suddenly passed and reared itself to a height of several thousand feet and floating off toward the east, quickly disappeared, to be replaced by another burst of vapor from the center. No fluctuation of the vapor was noticed as it rose so far as I could learn from the chief Nusha, the only instance of fire was ever seen. According to the diary of John Brown,* a miner who spent the winter of 1884-85 at Tard, the volcano was at that time in a state of somewhat violent eruption. He says:

"The volcano has been very quiet & good while, but today it is sending out a vast column of smoke and burbling smoke stacks high up of feet high in the air. The masses of coal rising up must be very large to be seen here. . . . It was once the world reported, only a sort of rumbling noise."

It is possible that an active volcano may exist east of Mount Wrangell in the upper White River basin, but our information as to this is so meagre and so vague and so unreliable statements of the Yakona natives—statements that may refer to Mount Wrangell. Some sharp cones were seen northwest of Lake Wapash and also some in the St. Elias mountains between Khatanga and Sea of Japan. The volcanic origin, however, could only be inferred, and any present activity would

*The Sources and Alps of Alaska, H. W. Selon Kart. London, 1887, p. 19.

have been concealed from us by the clouds which hung about the mountain.

Recent volcanic activity.

The most striking effect of recent volcanic activity in this region is the wide-spread deposit of volcanic ash, or tufa, which covers the southeastern portion of the Yukon basin. This deposit was first noted by Schwatka on his reconnaissance of 1883. It was more fully described as it occurs on the Pelly and Lewis by Dawson in his report of the Yukon expedition of 1886, and was noted by McConnell in 1887 and Russell in 1889 on the Yukon and Lewis.

It was first seen by our party on Teslin river shortly after leaving Lake Aukon, and from this point it remained fairly constant in amount and nearly continuous where found in cut banks of the river nearly down to its mouth, at the confluence of the Lewis and Pelly. Where first seen the layer of tufa was less than an inch in thickness and from this increased to a maximum of nearly a foot near the mouth of the Teslin, with some local accumulations of two or three feet. The accumulation which has formed upon the layer of tufa is generally about a foot in depth, but it was usually varied from nothing to three or four feet. A foot, however, probably represents the normal accumulation of sand under the prevailing conditions since the deposit of the tufa.

The first point at which the tufa was noticed in the White River basin was about one hundred miles southwest of Selkirk, on the divide between the Nainui and Dongk, eastern tributaries of White river. It is altogether probable that the deposit was continuous over the whole of this country, but no localities favorable for its preservation and display were seen on the high land traverses. A layer much heavier than that appearing on the Lewis would undoubtedly be steadily lost on a surface almost entirely destitute of soil and composed of rock fragments of varying degrees of coarseness.

In the basins of the Klondike and Dongk the tufa does not form a continuous layer as on the Lewis but is probably represented by certain stratified beds of white sand, which were regarded at the time as lake lay soils. They are indistinguishable from the sediment carried and deposited by the river at the present time, except in being somewhat coarser.

The original thickness west of the Denjok must have been at least several feet, and the increase is very marked toward the east. The tufa forms considerable alluvial fans at the mouths of the canyons of many rivers, among the cones of snow which form in similar position. After passing the Kaderu the narrow valleys were found deeply filled with tufa which had accumulated from the steep mountain slopes. From the divide the upper White River valley was seen stretching fifty miles to the westward, and appeared almost completely covered with drifts of snow. On reaching the valley the drifts proved to be tufa, which forms a deep mantle over the country north of the Stikine mountains, and for twenty miles west of the Kootenai forms a desert of drifting snow-white sand into which one sinks from four to twelve inches in walking. A scanty growth of dwarf alder and blackberry bushes has gained a precarious foothold in some places, and a few stunted spruce trees grow in protected spots along the streams. The tufa extends up the mountain sides on the south, covering every surface where the slope is not too steep for it to be laid down by melting snow to the level snow, which begins about 1500 feet above the valley or 6000 feet above sea level. The valley was covered with a sheet of gradual drift before the deposition of the tufa, and in places where the drainage is very imperfect. Many small lakes and ponds, usually without outlet, are scattered over the surface.

The greatest observed thickness to which the tufa deposit attains is between 75 and 100 feet. This was seen on the west bank of the Kootenai, where there is no reason to suppose that its original thickness has been increased at the expense of the surrounding regions except, perhaps, by wind drift.

Toward the upper end of the valley the thickness of the deposit decreases very rapidly, and at the entrance to Salmon pass, less than forty miles from its mouth, it appears as a narrow white streak in the forest of fir and spruce, exactly as it does among the Lewis and Clark, 300 miles to the eastward. The deposit also appears to decrease in thickness rapidly toward the north and there is no indication of any considerable area

of the gentle slopes of the valley or on the mesas north of White river.

The gradual increase in thickness of the deposit from east to west is never paralleled by an increase in the size of the fragments

As described by Dawson* from the Yukon, "It is a fine, sandy material * * * consisting chiefly of volcanic glass. * * * the greater portion of which has been drawn out into elongated shapes, frequently resembling the substance known as 'Pele's hair'" where first noticed between the Nisling and Klanton. It had the appearance of sand which results from the disintegration of a soft or coarsely crystalline marble, the individual fragments being from .5 mm to 1 mm in diameter. The average dimensions increase to the westward and in the Klontan valley the deposit contains many fragments of white vesicular pumice from two to ten centimeters in diameter, though the greater part is much finer, piecing from 1 mm to 5 mm in diameter. Nothing in the nature of true volcanic bombs was seen in the tufa, though their presence may have been overlooked.

Taking the approximate limits of the deposit, as observed in the Yukon by McConnell, on the Pelly and Lower by Dawson, and on the Teslin at Soda pass by the writer, it will be seen to cover an oval area, with its maximum thickness near the western extremity. The oval area, which is 100 miles long, is about 37 miles from east to west and 10 miles from south to north, or about 32,300 square miles. Assuming the deposit to be in the form of a flat cone with the above base and a vertical height of not fifty feet, its volume amounts to 165 cubic miles of material.

From the facts of the situation, as above stated, a fairly safe inference may be drawn as to the source of the deposit. The explosive eruption which produced the tufa probably occurred in the northern part of the Stikine mountains, near the source of Klontan glacier. As already stated, it was impossible to tell whether there is any present volcanic activity in this region. One conspicuous peak, of which the top remained hidden by clouds, was pointed out by the natives as having some unusual characteristics of which they seemed to stand much in awe. The name by which they called the mountain was Nul-ah-at, meaning, as near as I could make out, "shape of a head," but, owing to native reserve and lack of an interpreter it was impossible to obtain any satisfactory information concerning the mountain. Mount Wrangell has been suggested as the source of the tufa.

* Report of an expedition in the Yukon district, N. W. T., and adjacent northern portions of British Columbia, 1897. Ann. Rep. Geol. Surv. Canada, Montreal, 1898, p. 407.

and this is a very reasonable, as it has already covered the area covered by the deposit.

The strong winds prevailing in the upper White River valley during August, 1891 were from the west and were evidently of the same direct or indirect origin. It would be interesting to fix the date of the eruption, but it is impossible to do so with any degree of certainty. From a study of the relations of the two bodies on the Pelly and Lower Li Dawson says:

"While the eruption must have happened several hundred years ago, it can scarcely be supposed to have taken place more than a few hundred years before the present time." A similar conclusion is reached from a study of the cones on the White River basin. He correctly states for the position and scale of the eruption on the basis of the surface topography, and and supports it by a very satisfactory relation of the total mass of lava with the area of the surface of the lava field, which he is independent of such an estimate is impossible that about the same proportions have for any great length of time.

From a point of view the greatest thickness of the deposit is vast majority of the lava must have fallen on the surface of the Ketchikan glacier as well as on the snow field at its source. The fact that this has been a long time and the fact that the eruption and remaining on the surface of the glacier at a short distance from its front indicates an interval since the eruption sufficiently long for ice which had formed to have to flow down the length of the glacier and to deposit the lava on the termination point. As for the length of the glacier nor the rate of movement of its different parts is known, but the time required for the transport of material on the snow field to the terminus of the glacier must be at least several hundred years.

The character of the waters of White River has been noted by an observer on the Yukon who have passed its mouth. Schwatka* writes of it as resembling "a river of liquid mud of almost white color," and McFarlane† says: "The turbid character of the White river is far more than sufficient to prevent the growth of any life on the lower reaches of the river." The fact that the eruption has also shown evidence to prevent the recession of the glacier and to prevent the recession of the glacier and to prevent the recession of the glacier.

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* *Upper Alaska's Great River*. New York, 1885, p. 121.

† Report of an expedition in the Yukon and Mackenzie basins, N. W. T. and Alaska with special reference to the Yukon, by McFarlane, 1890, p. 144.

‡ See also *Alaska*, vol. I, p. 100.

green to a milky white.³⁴ This turbidity has been attributed to the glacial source of the river, but glaciers could scarcely supply such an enormous quantity of mud unless acting under peculiar conditions. The presence of this great deposit of unconsolidated material, which is being ground up by the ice as well as by the engorged streams, affords a ready explanation of the turbidity of the water. The highly vesicular character of the tufa permits a much larger amount of it to be held in suspension than of sediment derived from compact rocks.

Tertiary volcanic activity

Evidence of volcanic activity geologically recent though very much more remote than the eruption of the tufa deposit, is somewhat abundant. Perhaps the most striking example of such activity is seen in the basin between the junction of Peel and Lower rivers. This lava flow took place after the river valleys had been eroded perhaps below their present levels and extended entirely across the valley. The river has since cut through the barrier, leaving only a few fragments of the basalt resting on the granite on the western side of the channel. The lava flow probably came from two or more vents; one about ten miles north of Selkirk still shows the form of a symmetrical cone, and according to the native account has a small lake upon its summit, probably occupying the crater. A second vent was the high land on the western side of the Yukon about four miles north west of Selkirk. Between the Yukon and St. Lawrence black vesicular lava was seen at a number of localities, and north of the upper part of White river are broad mesas which appear to be formed of black lava. These are all probably of Tertiary age.

GLACIAL PHENOMENA

Ending Glacier

So far as known the existing glaciers of Alaska are confined to a narrow belt along the coast. Although the glacier of the coast and lies in the coast belt, this is not the sole or chief reason for the notable absence of glaciers in the interior, except in so far as climatic conditions are thereby modified. There are numerous points on the Yukon and its tributaries, particularly on

snow disappears in summer, although they have an altitude of from 6,000 to 7,000 feet and a mean temperature much lower than any portion of the southern coast. The explanation must be found in the very much greater precipitation and prevalence of clouds along the coast than on the interior.

The glaciers farthest removed from the coast are those flowing from the mountains of the Wrangell group, where the moisture-laden winds of the north Pacific are able to pass up the Copper River valley and across the coast range, which is some 100 or 150 miles toward the east.

From considerable glaciers descend a or nearly to tide level on Taku lake and river, though only Taku glacier entering the arms of the inlet, discharges bergs. A few miles up from the mouth of the river are two glaciers which come down into the valley nearly opposite to each other. Neither quite reaches the river but, like the Nares* glacier on the coast, they spread out into fan-shaped expanses as with low washed deltas of fine native material in front. Along the steep sides of the river valley above these glaciers a slight but distinct terrace has been cut about 150 feet above the river. It is probable that Wrangell glacier pushed across the valley to its northern side, dammed the stream for a short time after the main valley was clear of ice. A few Wrangell glaciers only a few small masses of ice or glaciers exist

in the Taku basin. The highest of the high mountains. No parts of the high interior present other than the Taku or Yukon basins, carry glaciers, and probably very little if any snow remains during the year between the Coast and Cassiar ranges, though much of the surface is fully 3,000 feet above the snow line at the coast. The reason for this rapid rise of the snow line toward the interior is the dry climate, with short but hot summers prevailing throughout this region. In like manner the high plateau east of White river is wholly free from summer snow, and the first glaciers seen on the Yukon basin were those flowing northward from the Stikine range. Kluantan and Porjek rivers are entirely head in glaciers, but these were not seen as they lay too far east of the route marked. Three large glaciers flow into the White River basin west of the Alaskan boundary and were easily seen on crossing following the southern bank of the upper White river.

* Named in 1888 for Dr Basil Norris, surgeon United States Navy.

† Named by the writer for Professor G. F. Wright of Oberlin college.

rise in the glaciers which I have observed to be a matter of two miles.

The largest glacier known to flow from within the Yukon basin is one which rises abruptly in the hinterland, descends the high range to the narrow range of the mountains which are from 10,000 to 12,000 feet high, and then gradually descends to the high peak on the northern border of the range called Natchikwiltuk mountains. It extends several miles down the foot of the range, though it is rapidly retreating at the present time, and is between 100 and 150 miles long when it reaches the valley. The retreat takes at the front of the retreating glacier is buried and a great accumulation of moraine material is abundant with a large and irregularly shaped mass of ice possible to determine the exact line of retreat. The heavy masses of vegetation which cover the front of the glacier retreats a mile or more beyond the margin of the ice, becoming gradually less abundant as the retreat portion of the glacier is approached.

The most important of the Khatan is the largest accumulation, by any of the interior glaciers. It is composed very largely of lignite, which is even better described by a lignite than by a coal, and many other fragments of any kind of rocks and a few of granite and gneiss. Much of the moraine has been removed by streams flowing from the glacier to a distance of 100 feet or more, and most of the extent of the moraine runs to the front and north of the valley.

The second of the White River glaciers is about midway between the Khatan and the second glacier. It is much smaller than the Khatan and does not push out into the valley, but its front forms a wall of ice extending over a great length from side to side of the narrow valley in which it lies.

The third and largest of the interior glaciers is the one which flows from the plateau northwest of St. Lawrence, down into the valley and from the valley across a line of feet which is a river and a streamer one toward Copper River basin. This was named in honor of Mr. J. C. Russell, whose explorations and survey of the St. Lawrence region during the past two years have added very largely to our knowledge of Alaska glaciers and to the science of glaciology. The northern or White River lobe of Russell glacier is buried under a heavy accumulation of moraine, bearing some vegetation, while the southern lobe is almost wholly free from moraine material and the exposed ice is located down to the

these the eastern appears to be retreat as much more rapidly than either of the others; but this eastern branch probably has its source in the same basin as the Frederikan glacier, and it seems not improbable that by some means the drainage of the latter has been diverted from the western to the eastern outlet thus causing the rapid retreat in the former glacier and a pause in the latter.

The large tributary glacier above referred to flows from the mountains forming the eastern foothills of the Wrangell group. After the union of its three branches the combined stream occupies the valley of the Nazenah for about six miles, crowding the river out of its channel and forming a large tilted lake above the ice barrier. Its great volume, together with the distance which this glacier pushes down into the valley, indicate an increased precipitation due to proximity to the top of the river valley through which pass the warm winds from the ocean.

No glaciers flow into the Chitnah valley from the ranges on either side, though all the upper portions of the Wrangell group are snow covered and doubtless the high mountains are filled with ice. Several large glaciers flow into the Upper River valley from the coast range, although its altitude is not so great as that of many portions of the interior plateau which is entirely free from permanent snow. The highest of these coast range tributaries of the upper river are Miles and Chilas glaciers, mentioned by Lieutenant Allen in 1885. Several others of considerable size higher up the river do not appear on Allen's map, probably because he passed up the river when the surface was still covered with snow. Miles glacier is quite comparable in size with those of the Mt. Elus region and is fed from and recessed by the same glacial conditions. It is evidently retreating at present, and the river opens out in a lake-like expansion at its foot in a part of the general channel formed when the ice has receded. This expansion of the river is about a mile in width and one mile is formed by the glacier front, a wall of ice 500 feet above the water and over five miles in length. Although the ice no longer reaches entirely across the valley, there remains a heavy lateral moraine, indicating its former position and damming back the river as above described. The fact that the river has cut only part way through the moraine indicates a very recent recession of the glacier.

Former glaciation

Like most of the other parts of the coast region, the Takus basin shows signs of intense glaciation from the westward-moving portions of the Cordilleran ice sheet. Evidence of this in the way of glacial deposits is wanting along the lower portion of the river, while the polished and striated rock surfaces so abundant there may be due to the action of a glacier occupying fully the river valley. The evidence of an ice sheet becomes more abundant, however, toward the upper part of the basin.

Thus, on a spur of the high plateau east of the forks of Takus River, bowlder clay and stratified gravels were seen 8,000 feet above the river. The movement of the ice in the greater portion of the Takus basin was apparently in the same direction as the present drainage. The high broad valleys of the upper Takus branches are deeply filled with a mantle of bowlder clay and gravel. In most cases this is a, more or less a comparatively

even layer over the surface, but also many narrow ridges occur, some to fifty feet in height, with the longer axes in the direction of the present valleys. These, however, probably mark a phase of deposition by a greater accumulation and was a general fact, so that they afford little if any indication of the extent

of ice movement during the maximum glaciation. A more better indication is afforded by the transportation of bowlders from the head of entire glaciation on the Takus to a point nearly half way across to Ahikien valley, a crossing of rivers of bowlders were observed composed of a porphyritic granite containing large porphyritic crystals of black hornblende. At this point there was found in a range of hills composed of the same granite, and no bowlders of this rock were seen to the northeastward. At the summit of the divide but little evidence was seen which would indicate the direction of the ice movement, though it seems probable that it was toward the north-west, as it certainly was in Ahikien valley.

Some deposits of true bowlder clay occur at various points along the lake, and a single occurrence was noted on the Teslin river about five miles from its mouth. Among the many lakes in the upper part of the valley are ridges and mounds of rounded bowlders and gravel, which, with terraces of the same material about the head of Ahikien, were evidently deposited by

a rapidly retreating glacier and the stream is toward it, and the gravelly layers are younger than the lower layers, which are older. The gravel is also younger than the sand of the river beds toward the north.

Among the most interesting features associated with the second period of glaciation in the north-west are those forming the moraine hills along the Teton and other tributaries of the Yukon. These are continuous throughout the western length of the Teton river, increasing slightly in height from about 40 feet at the lake to 100 feet at the mouth and frequently containing numerous drift ridges. The materials of which they consist are light-colored silts or fine sand and rock and water-laid, to three or four feet in thickness of tough brown clay. The layers of sand are often cross-bedded and contain a few centimeters of gravel material so sand-sable in size. At some places the radiolaria beds are slightly contorted while those above and below are undisturbed. Although the deposits differ widely from the typical glacial clay which it was not covered by, yet the radiolaria occur in large regular beddings, evidently brought to their present position by floating ice. The beds are usually capped by a bed of coarse gravel, ten feet or more in thickness, but sharply separated from the underlying silt by a coarse. More rarely, layers of coarse sand and gravel a few feet thick occur interbedded with the silt, usually toward the top.

This deposit is characteristically orange to red and is called the "red drift" of which Dr. Dawson has described an occurrence of many localities in British Columbia at the upper Yukon basin. He regards the red drift as a deposit of low water estuaries by waters containing glacial silt deposited by streams from the retreating or stationary ice front. The elevation of Atkasut is 2,500 feet and hence the upper limit of the silt in the Teton at the lower end of the lake is about 2,500 feet. The upper limit of the water silt, as observed by Dawson at various points in British Columbia and the Yukon basin, is between 2,400 and 2,500 feet,

indicating a subsidence of the plateau for a considerable period toward the close of the second period of glaciation. During this period of subsidence the present Lake Lahou was undoubtedly formed

by a flow of the retreating glacier which prevented the filling up of the northern end of the valley so occupied. It is with the retreat of the edge of the southern period, the lake was be-

much as it appears at present, only somewhat larger, its waters being held by the dam of silt which had been laid down in front of the ice.

Having in mind the conclusions of Lawson, McConnell and Russell as to the northern limit of glaciation in the Yukon basin, evidence on that point was carefully sought in the plateau region southwest of Selkirk. For the first one hundred and twenty-five miles the evidence was wholly negative. No sign of glaciation was seen, and this too in a country well calculated to retain the marks of ice action. The stream gravels consist of a very small number of rock species, and on following a stream to its head the source of each was easily found showing that no foreign material had been brought into the basin. While in general the surface contours are smooth and flowing, this is the result of long-continued subaerial rock disintegration, and generally the surface rock is evenly bedded beneath great accumulations of fragmental debris, though occasional sharp pinnacles and towers of rock project from the smooth talus slopes. Had this region been subjected to the action of an ice sheet during the glacial epoch, not only would the greater part of the rock débris have been removed but the projecting pinnacles would have been planed down to rounded knobs which would still retain pitted and striated surfaces.

Where Selkirk river was crossed its broad valley is filled with a deposit of coarse gravel and bowlders and from their great quantity and variety it was inferred that the stream had its source in a drift-covered region. The first undoubted evidence of ice, however, was found on the divide between Nisling and Klumtuck rivers where the northern edge of a sheet of boulder clay was passed. From this point southward the character of the surface suffers a marked change. It is no longer composed of the fragments of one or two kinds of rock occurring in place near at hand, but rather of many varieties coarsely mingled with clay and sand. The drainage system is imperfectly adjusted to the topographic surface, so that wide valleys carry small streams, and large streams like the Klumtuck and Deasek flow, for considerable distances at least, through narrow valleys.

The ice which has left its marks in this sheet of boulder clay was probably a continental glacier fed by streams coming from the south through narrow valleys now occupied by Klumtuck and Deasek rivers. These valleys so far as it appears to have been

glaciers high up their sides, and it is probable that these glaciers, southern portions of the interior plateau already described were not wholly covered by ice even when the former glacier generalization prevailed. The absence of a terminal moraine along the northern limit of the glaciated area would indicate that the Klondike valley was filled by ice from comparatively small streams bearing a large amount of material.

Southward from the Klondike valley records of former ice action continued to the coast,¹ but the glacier ice was by no means so intense as one might be inclined to expect from the high latitude of the region and the great altitudes of the neighboring mountains. The marks of the former general glaciation have been removed from many of the river valleys, or at least greatly obscured by the recent glaciers which have lately withdrawn from the valleys.

It seems probable that at the period of maximum glaciation the relative amounts of glaciation on the northern and southern sides of the district is not as were indicated earlier as at present, and taken as now by far the greater ice drainage was to the south. Some measure of the relative volume of the ice streams flowing in the two directions may be obtained from the relative amounts of moraine material which they have left. On the north, as already stated, there is no terminal moraine—only a comparatively thin sheet of bowlder clay south of the mountains; on the other hand a deposit of moraine material, at least several thousand feet in thickness was accumulated on the sea bottom in front of the glacier and is now shown, according to Russell, in the recent uplift forming the Chukchee

connecting upon the map the points which have been determined by various observers as the northern limit of the glaciated area in the Yukon basin. The position of the terminal moraine at the period of its greatest extension is approximately indicated. Striated rock surfaces were observed by Deussen on the Fly down to the point at which it crosses the Fly river and on the Lewes as far north as 61° 40'. Although he does not regard these as strictly limit points, still, in the light of facts observed in the plateau southwest of the Fly, Lewes and some of the river at least may safely be regarded as such. Melton and Russell also agree the limit of glaciation on the Lewes to be near the mouth of the Salween river, and my own observations led me to think it is at least as far north

as the limit. The point to which glacial extent is in the White River basin has already been indicated, with the evidence on which the limit has been based. The extent of the line west of

depending on a statement of Lieutenant Allen that he saw no till north of the Alaskan town camps, as he called the Tanana River valley. The line shows a part of whose northern limit is probably within it, and to some indication of dispersion of the material of fresh deposition, between the course of the Rocky mountains. From the center two stations north of the dispersion diverged toward the north and northwest along the axis respectively of the Rocky mountains and the St. Elias range, while the non-glaciated area formed a deep crevasse in the Yukon basin between these convergent lines. The northern limit of glaciation is shown approximately in plate 18.

It is probable, however, that many lines from the main glacier extended down the valleys beyond the limit above indicated, while the correlative sheet was not so thin. It is toward its northern limit to overcome the greater irregularities of the surface. It is the White River valley at least, and have been seen only the well north of the general glacier from even after a considerable amount of recession had taken place. The breadth of the valley at the mouth of the Stikine is about 2,400 feet so that it must have formed an estuary during the period of its extension marked by the white st. deposits, and the formation of Lake Wellsley is probably analogous to that of Lake Athabasca.

APPENDIX

CRYPTOGAMS COLLECTED BY LIEUT. WILLARD HAYES IN ALASKA, 1891.

ALASKA, U. S. M. M. 1891.

ALGAE.

Lycopodium complanatum, L. Taku, June. A small fern with

leaves.

Sphagnum teretifolium, Hedw. Prince William Sound, September.

Sphagnum montanum, Ehrh., var. *maritimum*, Schreb. Taku, June. A
small fern.

Polypodium fulgens, Turcz. Prince William Sound, September. On ex-
posed rocks.

Heterospora angustata, Hedw. Prince William Sound, September.

Pteridium aquilinum, Turcz. Prince William Sound, September. Sterile.

Therapsid pedunculata, Hedw. Prince William Sound, September. Small
plant, on rocks.

Vespa pomatorum, Hedw. Prince William Sound, September. Small
plant, on rocks. Schreb. Taku, June.

Polypodium commune, L. Prince William Sound.

Pteridium aquilinum, Hedw. Taku, June. Male plant.

Hypnum Pringlei (Hedw.) Hedw., L. Prince William Sound, September.
Sterile.

Cladonia coccinea, Hedw. Prince William Sound. Sterile.

Cladonia Peltata, Hedw. Prince William Sound. Sterile.

Cladonia Peltata, Hedw. Prince William Sound. Sterile.

PLANTS.

Erigeron phillyriae (Hedw.) Hedw. Prince William Sound, September.

Erigeron phillyriae (Hedw.) Hedw. Prince William Sound, September.

Erigeron phillyriae (Hedw.) Hedw. Prince William Sound, September.

Erigeron phillyriae (Hedw.) Hedw. Prince William Sound, September. A species
not before recorded in the Arctic region of Alaska.

Erigeron phillyriae (Hedw.) Hedw. Prince William Sound, September.

extending from Taku up about 1000 feet to the west. The total number of strata from Taku is twenty, the eleven were a chance, as Prince Williams found. It is likewise that the period from about 1000 up to the Tumen River is considered by the geologist to be a period of about 1000 years, and is the western coast.

It is greatly to be regretted that all the valuable collections made by Dr. Hayes were in the interval and to be a much more because of lack of means of transportation.

In the collection of these plants I have seen a list of the plants for and to the forest L. M. (underneath), who made some of the plants, and to the forest L. M. (underneath) who is reported several of the plants with the collection of the Tumen interval. (Hayes)

WILKINSON, 1900, 1901, 1902, 1903.







